INVESTIGATION OF AN APPROPRIATE METHODOLOGY FOR PRESERVATION OF TRADITIONAL SRI LANKAN MURAL PAINTINGS

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INVESTIGATION OF AN APPROPRIATE METHODOLOGY FOR PRESERVATION OF TRADITIONAL SRI LANKAN MURAL PAINTINGS

Content of the thesis: Testing of validity and applicability of the hypothesis '*it is possible to reduce the rate of decay of mural paintings and probability of generation of defects in them by controlling their behavior*'

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DECLARATION

I do hereby declare that the material present in this thesis was resulted from research exclusively carried out by me under the supervision of Prof. T.K.N.P. De Silva. The thesis contains the results of my own independent research except where due references have been made. Persons who provided technical assistance for my research work are duly acknowledged. This thesis has not been previously or concurrently submitted in whole or part to any university or institution for the same or any other degree.

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Date: Sep. 23, 2005

I certify that the work reported in this thesis was carried out by the candidate, is of suitable standard for the degree for which it was submitted and worth of consideration.

Prof. T.K. Nimal P. De Silva,
Supervisor

Date:

Publications by T.D.N. Perera relevant to the thesis

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2. 2004, 'A non-destructive method to measure the rate of decay of mural paintings', *Built environment Sri Lanka,* 4, 2, pp. 55-58

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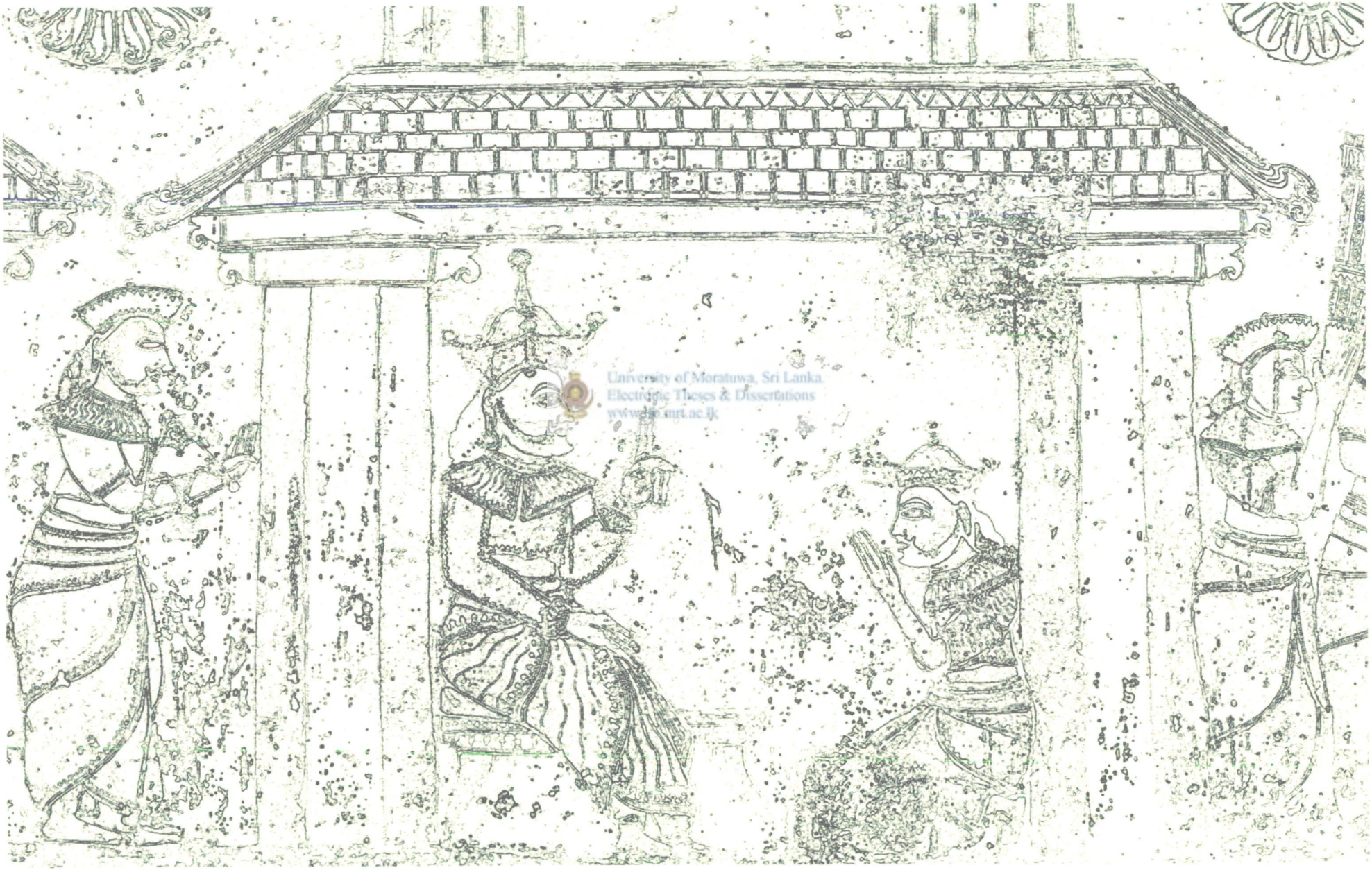

ABSTRACT

This research was founded with an objective of finding the most effective method of preservation of traditional Sri Lankan mural paintings. Investigation was separated into three main areas. These are determination of necessary actions in preservation, investigation of preservation mechanisms and investigation of applicability of these methods. Actions needed in preservation were identified by analyzing present condition of paintings. Paintings were classified into several logical groups to facilitate analysis. A criterion for classification was developed considering all possible factors of sorting. Classification of paintings according to the period of production was the most appropriate criterion since this automatically classified paintings on technique, school, climate, pattern of decay, pattern of deterioration and the degree of deterioration. Analysis of condition of paintings disclosed following facts:

1. all paintings are in a rapid rate of decay
2. deterioration is a result of natural decay and accelerated decay due to dilapidation
3. intervention based on synthetic resins prevented fragmentation and loss of material but accelerated the rate of decay

This information led to the decision that adequate repair and prevention of deterioration would be the most needed actions in conserving Sri Lankan paintings. Analyzes of these facts emphasized that there was a definite need to develop a viable method of reduction of the rate of decay of paintings. Development of the most appropriate method needed following background information: principles of traditional technology; social aspects that led to creation, usage and maintenance of paintings and traditional methods of conservation and maintenance. There were few direct and indirect sources to gather this information. These were traditional technical texts, historic records, legend memory and information generated from physical and chemical analyses. Present social conditions that led to survival and destruction of paintings were also analyzed. Technical analyses were based on structure, composition and behavior of Sri Lankan paintings and survival and performance of different types of paintings in different climatic zones. Most appropriate chemical and physical analytical methods were used in the analysis.

Constant nature of structure, composition, production process and procedure of painting in paintings belonging to a particular class and analogy among different classes indicated strict adherence of production techniques to rules and regulations of traditional technology. Seven major Sri Lankan painting techniques were identified. Classical, medieval and southern are the dominant techniques among them. The most major difference among these techniques is the structure and composition of ground. Two major techniques were therefore defined based on the usage of the process of carbonation in the ground. The characteristic feature of Sri Lankan painting techniques is the use of biotechnology.

A heavy amount of microbiological actions and enzymatic reactions had been used to attain key properties not gained by other means. Use of most stable material is a law of traditional technology. Certain principles of traditional technology that realized appropriate coordination between paintings and environment were identified. A particular traditional painting technique fulfilled the needs of the corresponding painting school and users of paintings produced by that technique. Usage and maintenance also followed definite rules, regulations and guidelines. These were identified by analyzing later modifications to paintings.

Special attention was given to understand actions occurring in paintings. These actions were identified as interactions of paintings with the environment. Interactions with environment and response of paintings to these interactions were defined as behavior. Water transmission and thermal movement of paintings were identified as main actions of behavior. These dynamic physical actions bear on most other physical, chemical and microbiological actions. Paintings on masonry and wood support absorb water through support, transmit towards the surface and evaporate on the surface. Paintings on rock support absorb water through the surface and disperse throughout the ground. Porosity of ground and permeability of paint layer are important parameters in both of these absorption types.

Most actions occurring in paintings are detrimental to them and called actions of decay. Few favorable actions called actions of preservation were also identified. Various factors become favorable or detrimental in specific ranges and combinations with other factors. Decay is a continuous process associated with every painting. Decay results in a change of material, material properties and structure. These changes bring about deterioration, i.e. formation of defects. The rate of decay accelerates with the formation of defects. Behavior of every painting becomes destructive with the formation of defects.

Prevention of decay is the principle action necessary in preserving paintings. This is the key task necessary to preserve deteriorated traditional mural paintings. Prevention of fragmentation and loss of material are other important needs. This investigation was centered on determination of the most effective method of minimizing the rate of decay. Simulated samples of paintings were used in the investigation. Production processes of these simulated samples were determined using information obtained from traditional technical texts and chemical and physical analyses of samples of paintings. It was found that two types of samples could represent all Sri Lankan paintings. These are samples with lime ground and samples with clay ground. It was decided to produce samples at four categories of increasing complexity to reduce errors during analysis. Elementary samples simulated the painting ground, basic samples simulated the multilayered structure of paintings and advanced samples simulated complex structure of paintings. Advanced samples had heterogeneous paint layers and complex ground.

Representative samples represented the actual paintings. Enzymatic and microbiological actions mentioned in traditional technical texts were used to produce representative samples.

This investigation needed methods to measure behavior and the rate of decay. Behavior could be adequately measured using parameters of main actions of behavior. An indirect method based on intensity of defects and difference in hue was used to measure relative rates of decay. Methods of reduction of rate of decay tested were removal of factors of decay, environmental control, repair of defects, induction of equilibrium behavior and few specific actions of preservation. These different methods were successful at various degrees. Removal of some factors of decay reduced the rate of decay at all instances. However, it had a limited amount of success due to the fact that total removal of some factors like water and thermal energy increased decay. Environmental control remarkably reduced the rate of decay. However, this did not guarantee the long-term existence of paintings. Furthermore it was difficult to adopt. Natural actions of preservation takes very long durations and difficult to manage. Maintaining conditions that enhancing these actions was the only external intervention possible. Further analysis of these methods of reduction of rate of decay disclosed the fact that all of these mechanisms were effective when they induce equilibrium. Special attention was therefore given to test possibility of reducing the rate of decay by inducing equilibrium behavior. Existence of a relationship between the degree of equilibrium and the rate of decay was the main hypothesis tested in this research.

Relationship of equilibrium behavior and the rate of decay was studied at four levels using four categories of samples. A completely randomized design was used. Relationship between behavior and the rate of decay was tested with elementary, basic and advanced samples. Behavior was changed by altering input physical factors. A distinct relationship was observed. Relationship of degree of equilibrium with the rate of decay was also investigated with these samples. Equilibrium was quantitatively changed by allowing the samples to absorb moisture at different known rates under different known temperatures and relative humidity. A definite correlation existed. These relationships were significant ($p<0.5$) or highly significant ($p<0.1$) in each category of all types of samples. Definite relationship existed between the degree of equilibrium in behavior and rate of decay of traditional paintings was established with a high confidence level. It was found that the degree of deviation from the optimal equilibrium is the factor that determined the rate of decay. Further analysis done with representative samples disclosed the fact that each painting technique has a set of optimal ranges of equilibrium. There is an optimal point of equilibrium for each action and optimal range of overall equilibrium in each class of painting. This optimal level could be defined in terms of input parameters. Optimal level of equilibrium for each technique of painting could therefore be determined.

Equilibrium reduced the probability of generation of defects. Equilibrium at optimal level reduced the rate of decay too. Analysis of mechanisms of reduction of rate of decay disclosed the fact that all methods of reducing the rate of decay minimize decay by inducing equilibrium. It was therefore emphasized that induction of equilibrium at the optimal level is the most effective method available to reduce the rate of decay of mural paintings. Mechanism of reduction of rate of decay by induction of equilibrium behavior was investigated using simulated samples. Paintings in equilibrium maintained all factors at their moderate rates. These intermediate levels approached optimal levels of most actions. Equilibrium brought about proper coordination between all actions. It did not allow any action to grow beyond the favorable limit. It reduced tear and wear. It tremendously decreased the probability of formation of defects. These factors are important to all paintings.

Method of inducing equilibrium behavior at the most optimum level is called stabilization. Possibility of practical induction of stabilization was tested on simulated samples. All possible methods of stabilization were investigated. These are repair of defects, environmental control and application of controlled amounts of input factors. All ancient paintings have defects as a part and parcel of their structure. Adequate repair of these defects is compulsory. Special emphasis is therefore given to test possibility of stabilization by repair of defects. Samples were subjected to destructive intervention to generate defects. Their behavior was measured and compared with normal samples. Repair was done with traditional material and synthetic material. Quality of repair done with synthetic material was better than traditional material. Quality of repair with traditional material was also at an acceptable level. Repair with synthetic material however deviated behavior away from equilibrium. Repair with traditional material was effective in bringing equilibrium closer to the original level.

It was therefore decided that repair of defects with traditional material could reduce the rate of decay of traditional mural paintings. Possibility of practical adoption of the method was also investigated in five selected sites. Necessary actual measurements were done; conservation plans were developed. It was found from this study that repair of paintings with traditional material and maintaining their environment within acceptable ranges were adequate for stabilization. Elaborate measurements were not necessary to adopt the stabilization method. It was established that the stabilization method can be adopted as a systematic process of reduction of rate of decay and decreasing the probability of emergence of defects.

PREFACE

The objective of performing research in the field of painting conservation is the desire to study natural actions without set artificial boundaries within different fields. Painting conservation is the field where researchers enjoy the freedom of performing research without restrictions under a defined field. This essentially demands and promotes a multidisciplinary approach. Research in painting conservation is however a challenging task. Complex nature of paintings brings about a vast number of interrelated actions that analysis becomes difficult. This research is primarily concerned with the actions necessary to arrest the natural action of decay. Analysis of complex behavior, decay and deterioration as a singular sequential process was the mechanism used in this research. The study concentrates on nullification of decay actions by the coordinated functioning of paintings with their respective environments.

Preservation is the most essential attribute in architectural conservation and hence in conservation research. This study primarily investigates traditional Sri Lankan mural paintings and their preservation methods. Principles of traditional technology applied during production of paintings, usage and maintenance are taken as the basis for the development of viable preservation methods. Preservation methods are analyzed in relation to the interaction of paintings with their environment. It was understood that conservation measures perfectly suited for modern paintings destruct traditional paintings. This is a result of difference in mode of interaction of these paintings with the environment. Root of the problem existing within present methods of conservation lies on this factor. Preservation method developed in this research took this fact into account.

Main obstacle met in this research was the random nature of variables encountered. Inherent random nature is a result of various combinations of factors involved. A similar problem exists in biology and medicine. Biostatistics is used in research in these fields. A similar approach was used in this research. Limitation of intervention on genuine paintings to a minimum was a major objective in this study. Simulated samples were used to realize this goal. These samples provided the additional benefit that tests could not be carried out on genuine paintings could be performed on them. Special attention was taken to produce samples that accurately simulated genuine paintings. All techniques of traditional mural paintings are included in the study. Attributes common to all these paintings and contrasting features could therefore be identified.

Content of the thesis is original materials generated from laboratory and field investigations. Sources of information gathered from literature survey are duly acknowledged. Analytical research was carried out at the ACOMAS Laboratory of the Department of Architecture and the Microscopy Laboratory at the Department of Materials Engineering. Sites where investigations were done are mentioned in the thesis.

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CHAPTER BREAKDOWN

This thesis consists of seven chapters. Content in each chapter is given below.

Chapter One: The present context of traditional mural paintings

The fist chapter contains the results of a preliminary analytical study of the remaining traditional Sri Lankan mural paintings done with an objective of identifying the research problem. Empirical information obtained is presented under characteristic features of mural painting tradition, conservation and maintenance practices adopted during different eras, results of these actions, present condition of paintings, survival and necessary research in preservation. It finally deals with the necessary areas of research.

Chapter Two: The structure, behavior, decay and conservation of mural paintings

The second chapter contains information obtained from a survey done to identify methods available to solve problems mentioned in chapter one or to develop such methods. This information is categorized under structure and composition of paintings, mechanisms of decay, methods of conservation intervention, results of intervention and methods used in conservation analysis.

Chapter Three: Preservation of decaying paintings

An accurate understanding of interaction of mural paintings with their environment was the initial task necessary in this research. This chapter contains methods used in such analysis, results and inferences realized. Content of the chapter is categorized under actions of behavior; processes of behavior; decay; patterns of behavior, decay and deterioration and mechanisms of survival. It finally deals with the methods of solving the research question. The method of investigation and experimental design are included in this description.

Chapter Four: Investigation of methods of reduction of rate of decay

This chapter describes the research methodology used in testing of hypothesis, results obtained from this investigation, inferences and conclusions realized. Information present in the chapter is divided into following areas: production of simulated samples, methods used in the measurement of behavior and decay and testing of mechanisms of reduction of decay. The chapter finally deals with the most effective method identified.

Chapter Five: Investigation of methods of intervention to stabilize behavior of mural paintings

This chapter contains information on the investigations carried out to identify relevant methods of implementation of the theoretical method. The chapter is arranged on following sub topics: impact of behavior on paintings, investigation of methods and results of intervention.

Chapter Six: Investigation of applicability of stabilization: case studies

This chapter consists of descriptions about research done in specific sites. It deals with the applicability of selected methods of intervention on selected sites. Investigation done in each site is described separately with developed conservation plans. The chapter contains material on following topics: methodology of investigation, findings and plans of preservation.

Chapter Seven: Systematic conservation of mural paintings

The final chapter contains conclusions drawn out from analyses. This discussion is divided into following topics: analyses necessary in preservation, relevant actions of intervention, methods of repair of defects, methodology of minimization of decay and stabilization of monuments in the built environment by enhancing their user values. Procedures of preservation of different paintings are described in detail.

INTRODUCTION

Painting tradition is one of the most vital traditions that reveal technological advancements and social status of a nation. This unique tradition is most penetrative in understanding technical and social attributes in Sri Lanka since it signifies the activities and development of human society lived in the island from pre-historic times. Nation and hence tradition had developed in the island in isolation but with an influence of foreign elements from time to time. An ample amount of remains of paintings is still available to understand continuity, technical developments and chronological evolution of painting styles and techniques. Most remaining paintings are in a good condition although associated with complex problems regarding survival.

The technical and artistic formulae that produced traditional Sri Lankan mural paintings is separated into certain painting techniques and schools. Paintings produced by them are present in buildings of many architectural forms. Diversity is the characteristic property of Sri Lankan paintings. Diversity is present in material usage, production techniques, composition, painting styles and edifices paintings exist. Different styles of paintings represent different painting schools that existed in chronological order. A school might have been lasted for several generations. A particular painting school had been bound to a definite painting technique. Different painting techniques therefore contain technical entity of different painting schools. Techniques and styles are therefore directly related. Separation of paintings according to the painting style is therefore justified. Since this relationship is highlighted in different political periods, it is possible to categorize all Sri Lankan paintings under period of production.

Mural painting tradition was related with other contemporary traditions and shared available technology with them. Paintings had been produced to fulfill requirements of the society making use of highest available technology. A team of artists had been operational in a particular site. This team worked under a master artist. Students and apprentices were other members of this team. All tasks regarding processing of material and production of paintings had been done by these artists. Their responsibility had not been lasted after finishing the product. Maintenance and conservation had also been done by artists appointed for the task. Paintings in shrines were objects that had secured as sacred religious items. Royal patronage had been received during production and continuously afterwards.

Mural paintings are objects that represent attributes of traditional technology in the highest form. Paintings provide material to analyze traditional technology, mechanisms of decay and decay products. These are valuable cultural objects of the nation. Most of these are protected religious icons still in use. Traditional paintings denote the art history. These indicate the past social system.

Traditional paintings are sources of valuable analytical information for the scientist and artist. These allow investigation of many relationships with a magnitude due to their higher sensitivity. Conservation of them is therefore an unchallengeable issue.

Paintings faced relatively few problems when they were under maintenance of traditional technology that produced them. Some paintings were in an abandoned state afterwards while some others were under maintenance and others were subjected to harsh elements. Some paintings had begun to deteriorate at an accelerated rate as a result. Paintings have to survive in a polluted environment at present. Influence of sources of mechanical energy is also high. Paintings in coastal areas are exposed to salt. Climate has been changed undesirably. These factors have contributed to an increased rate of decay. All traditional mural paintings are in different degrees of deterioration as a result. These are not in an acceptable state of preservation. Paintings had received attention with the advent of conservation methods based on chemicals in mid-twentieth century. External appearance of paintings had improved by cleaning with chemicals and fragile areas were fixed using resins. Paintings survived without fragmentation and collapse due to this intervention. These methods of conservation in practice to date are based on repair of defects as and when these appear. These do not adequately fulfill the long-term needs of preservation.

Sri Lankan paintings are in a fast rate of deterioration and methods used in conservation are unsatisfactory. Whole conservation process needs to be analyzed with a wider perspective. Analysis needs to include traditional technology, social attributes connected with paintings, needs of present user and usage of modern technology. Correct identification of technology that produced paintings is the prerequisite of conservation research. This gives accurate information on context of paintings, actions occurring in them and future proceedings. Identification of methods used in maintenance and conservation is also necessary. Determination of traditional method of usage is also a compulsory need. Understanding of traditional principles that produced paintings gives key information. Principles of traditional technology that produced paintings and used in conservation and maintenance will provide necessary guidelines in developing a viable preservation method. When traditional technical texts are available, determination of traditional principles becomes a straightforward task. When these are not available, this can be indirectly realized by analyzing structure and composition of paintings. Structure of paintings is the product of traditional principles. In the absence of any other source of information, methods used in maintenance and conservation can be understood only by analyzing layers of paintings added after original production. Information may be obtained by analyzing deteriorated layers underneath over-paintings, evidence of repainting, indications of cleaning and deposits present on layers. It is understood that usage of paintings during traditional era had been identical to present usage. Practices in the image house are therefore essentially similar.

Analysis of attributes mentioned above gives sufficient information to understand the relevant approach in developing a preservation methodology. In addition, it reveals technical background necessary for synthesis of preservation methods.

An accurate understanding of present condition of paintings is necessary prior to any attempt of conservation. Since paintings are a heterogeneous group, classification is necessary under a meaningful criterion. Intervention necessary for each class of painting may be determined with generated information. Actions that bring about deterioration of paintings have to be analyzed and mechanism of these actions deduced to find the way of developing a preservation method. Conditions of decay have to be analyzed according to mechanisms of decay in paintings. Conditions of preservation can be decided with this information.

Paintings need appropriate repair of defects, prevention of migration of defects, prevention of degradation of material and prevention of deformation of structure. Protection, preservation, repair, enhancement of quality and usage are the main attributes of architectural conservation of paintings. Methods used in intervention need to be reversible while recognizing authenticity of paintings, their producers and users. Preservation is the appropriate actions taken to ensure continuation of paintings in their current form. Preservation needs to protect compounds present in paintings, prevention of alteration of properties of these compounds and protection of structural form. Every ancient painting has defects. Repair is therefore an essential action in conservation. Usage is also a main requirement in architectural conservation. Improvement of quality of degraded products is necessary for their proper usage. This can be done by cleaning and reintegration. A preservation mechanism that can be used for all paintings but has flexibility of modification to fulfill different needs is most useful. Such a method is necessary for efficient utilization of available resources. In addition, the method must address other attributes of conservation equally well.

International research on painting conservation has been centered on analysis of mechanisms of formation of defects and relevant repair methods. Attention has been paid recently in minimizing decay by maintaining paintings under appropriate conditions. It is emphasized here that this preventive maintenance is the most vital aspect in preservation of paintings. Attention is therefore necessary in a broader margin to analyze possible methods of preservation by minimizing the probability of formation of defects. All methods available in preservation have to be tested to select the best one.

A primary need in conservation research is not disturbing artifacts during investigation. Destructive analysis has to be reduced to a minimum. Information necessary for research may be obtained from alternative sources. Such an investigation needs samples to carryout tests for which genuine paintings cannot be used.

Detailed analysis is necessary to determine the production process of samples. These samples need to accurately simulate their genuine counterparts. Theories involved in preservation can be tested on them. Methods of preservation based on these theories must have following attributes:

1. they must ensure long-term preservation of paintings
2. degree of intervention must be below the minimum acceptable level
3. intervention must direct paintings to their most natural state
4. intervention must be capable of performing with acceptable amount of material and methods
5. material used must be compatible with original material of paintings

Methods of preservation determined using simulated samples had to be tested on genuine paintings. Adoption of such a mechanism is possible only after the proof of its long-term benefits. This research was founded with an objective of finding the most relevant preservation methodology.